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Application of Soft X-ray Laser Interferometry to Study Large-scale-length, High-density Plasmas*

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Over the past few years we have demonstrated the validity and reliability of soft x-ray Mach-Zehnder interferometer, using a neonlike yttrium x-ray laser at 155 Å as the probe source, to study large-scale-length, high-density plasmas. We are now using the interferometry technique as a mechanism to validate and benchmark our numerical codes used for the design and analysis of high-energy-density physics experiments. In this paper we present recent experimental results on the studies of colliding plasmas and exploding foils. The understanding of the collision and subsequent interaction of counter-streaming high-density plasmas is important for the design of indirectly-driven inertial confinement fusion hohlraums. Using a 1-ns temporally squared pulse with an intensity of 3 x 10^{14} W/cm^2 incident on thick gold slabs with separations of 500 – 1000 μms, we observed a peaked density profile at the symmetry axis with a wide stagnation region with width of order 100 μm. The measured density profile falls in between the profiles calculated by the single-fluid radiation hydrodynamic code LASNEX and a multi-specie fluid code which allows for interpenetration. We have also used the interferometry setup to measure the local gain and electron density of yttrium x-ray laser amplifier. To simultaneously measure electron density and *local* gain under lasing conditions but with minimal refraction, we produced a 1-mm-long yttrium line plasma which was employed as an amplifier for a separately-produced, primary yttrium x-ray laser. Measured gains in the amplifier were found to be between 20 and 35 cm^{-1}, similar to predictions and indicating that refraction is indeed the major cause of signal loss in long line focus lasers. Images showed that high gain was produced in spots with dimensions of ~ 10 μm. We believe that this is caused by intensity variations in the optical drive laser. Interferometry indicated that density variations were not a significant factor so that temperature variations were responsible for the localized gain regions. The fact that much of the laser gain is produced in small regions may place a limitation on the coherence available from plasma-produced lasers.

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